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(54) Hydraulic machines

(57) A positive-displacement hydraulic-power converter, or transformer, includes a motor 1 driving a pump 2 directly through a shaft 7, the displacement rate of the motor and /or the pump being variable. The motor and the pump may of the sliding vane type (as shown), the eccentricity of the stator rings 4, 5 being variable. Alternatively, each machine may be a reciprocating one of either the swash-plate type, the swash-plate angle being adjustable, Fig. 2 (not shown), or of the rotating radial piston-and-cylinder type with a radially-movable stator-ring, Fig. 3 (not shown). As another alternative the rotors of the sliding-vane motor and pump may be disposed concentrically with a common eccentric stator-ring therebetween, which can be shifted radially, Figs. 4 and 5 (not shown). As a further alternative one machine may be reciprocating and the other rotary.

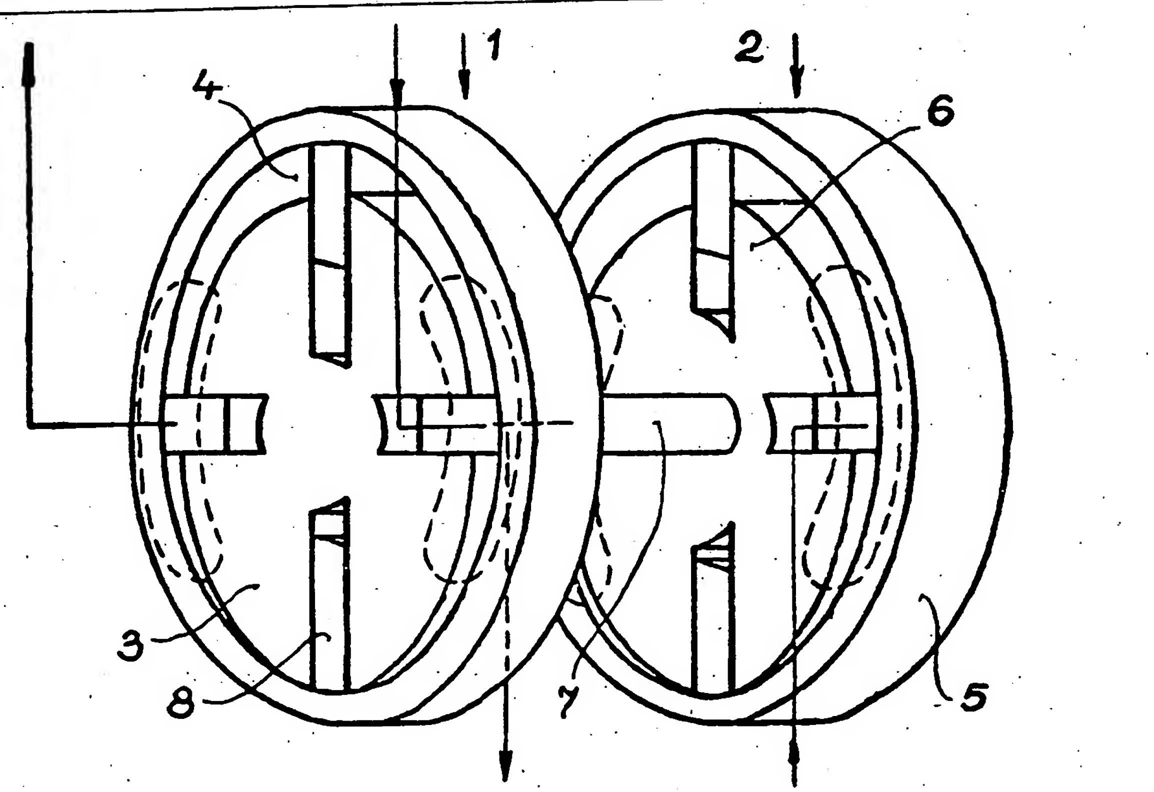

Fig. 1

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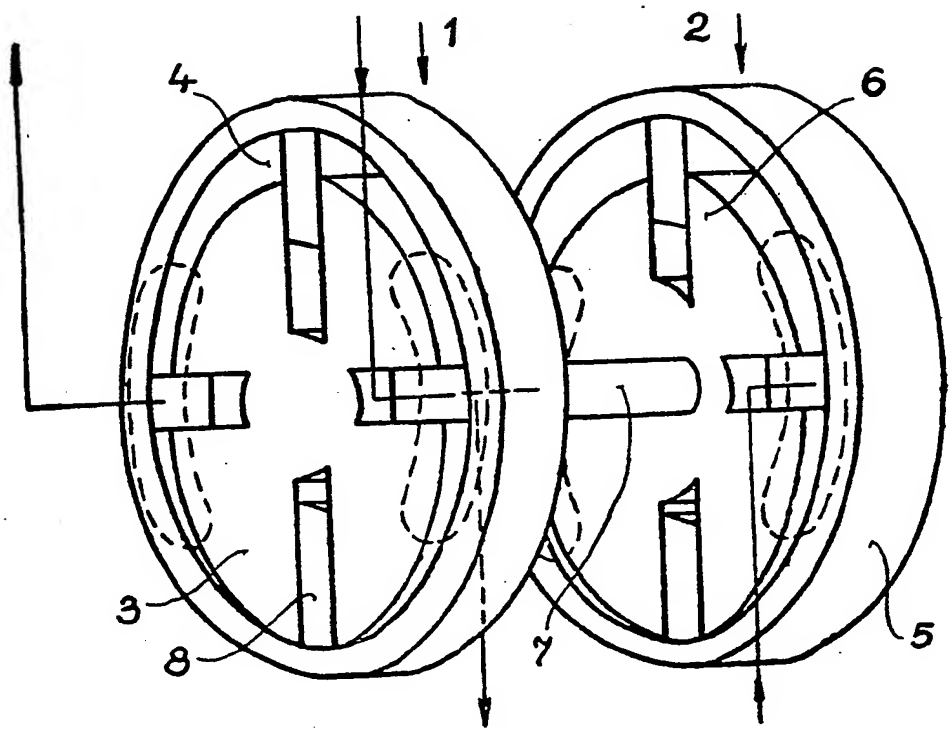

Fig. 1

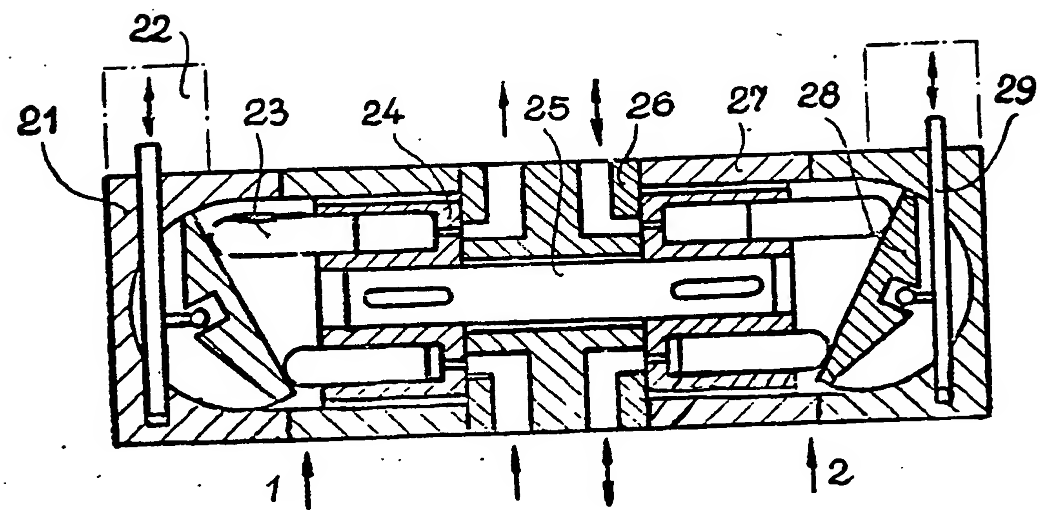

Fig. 2

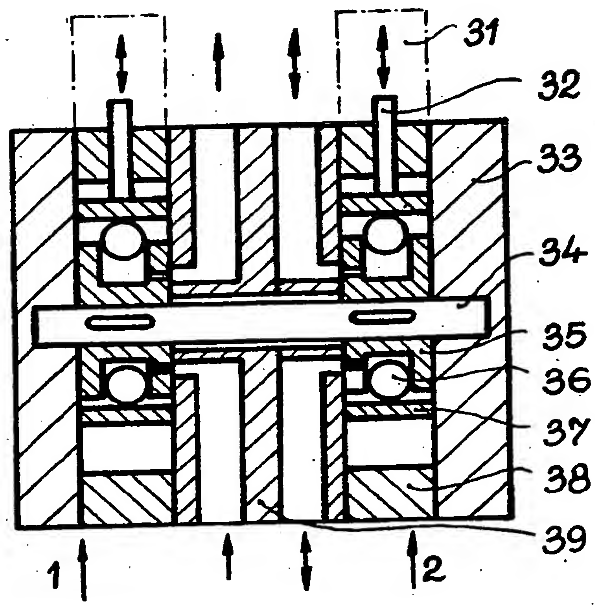

Fig.3

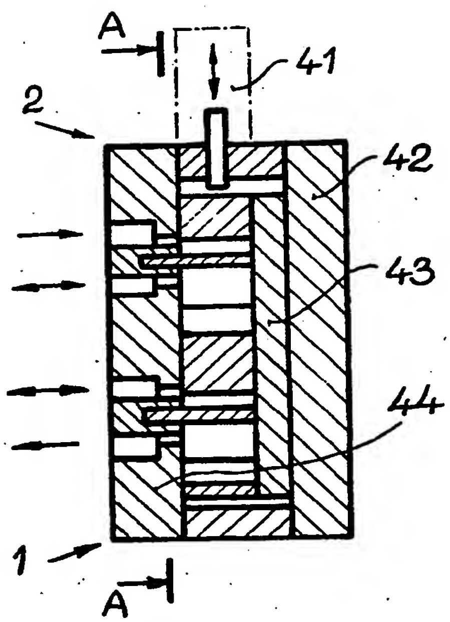

Fig. 4

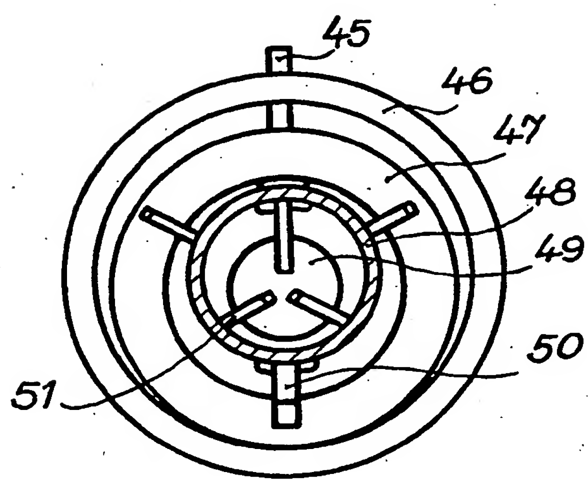

Fig.5

SPECIFICATION

Hydraulic machine

The invention concerns an hydraulic machine, more particularly a converter or transformer, the primary side of which has an hydraulic motor and the secondary side of which has an hydraulic pump.

Direct current (unidirectional) hydrostatic energy-transmitting cycles are generally of two basic system types. One is the closed system, while the other is the open system. It is a frequent requirement regarding these cycles that the operational characteristics of their work-performing elements should be variable; as a minimum, the velocity or the direction of the linear displacement, or both together, should be variable.

According to the present state of the art of hydrostatic engineering, these requirements are met in closed systems by stepped (indexed) or continuous (stepless) variations of the volumetric characteristics of the pump or motor. In a known solution, the volumetric characteristics of the pump can be changed simultaneously. Less frequently, the requirement of controllability in order to enable the angular or linear velocity to be varied is achieved by variation of the number of revolutions per minute (r.p.m.) of a constant-volume pump. Also, the direction of the linear or rotary movement may be changed with the aid of a mechanism suitable for controlling the volumetric characteristics wherein an adjusting unit is displaced through and over the zero (null) point in a negative direction. The changing of the direction of rotation or linear movement is usually achieved by the application of a system of slide valves or shut-off valves, or in some cases changing the direction of rotation of the external drive of the pump.

Due to the fact that the variation of speeds is performed by changing the volumetric characteristics, the efficiently of the closed systems is generally good.

In open cycles, where a constant quantity of liquid is delivered, the velocities are changed by employing variable throttles, as a consequence of which the efficiency of the system is poor. The control of the variations of the direction is performed, similarly to the closed cycles, by a system of slide valves or shut-off valves or less frequently, by changing the direction of rotation of the external drive of the pump.

It is a common drawback of both systems that if only one pump is operated in the system, the parallel operation of a plurality of independent working elements of the system is only possible by building special elements, e.g. flow dividers or flow stabilisers into the system. This, however, renders the system complicated and expensive.

An aim of the invention is to eliminate or reduce the above-described drawbacks of the known systems and to provide a control mechanism which integrates, by simple means, the functions of controlling displacement and supply quantity (flow rate) and, optionally, of limiting the pressure and distributing the flow.

The invention accordingly consists in a hydraulic converter or transformer the primary side of which includes an hydraulic motor and the secondary side of which includes an hydraulic pump. In one non-limiting aspect, the essence of the invention may be regarded as being that the drive shaft of the primary side motor and the drive shaft of the secondary side pump are drivingly coupled together so that they cannot rotate relative to one another and at least one of the motor of the primary side and the pump of the secondary side is in the form of an hydraulic engine of variable geometric working volume.

The invention thus seeks to achieve control of the flow rate by variation of the volumetric characteristics, therefore the hitherto open cycles or part-cycles may be converted into closed cycles, thus minimising the energy losses of the system.

During the operation of the converter or transformer, the change in the rate of supply of the working medium (oil) is proportional to the change in the working volume. In the zero-point (neutral) position of the control or adjusting element, there is no delivery of liquid, while if the said element is displaced beyond the zero point in the negative direction, the supply rate is proportional to the displacement but in the opposite sense. In this way a change of direction is achieved and the required velocity is set to be proportional to the displacement.

According to the preferred embodiment of the invention, at least one of the primary-side hydraulic motor and the secondary-side hydraulic pump is formed or provided as an hydraulic engine with a bladed rotor and with a cylindrical annular stator encompassing the bladed rotor, wherein the stator may be adjusted radially relative to the rotor.

In another preferred embodiment, at least one of the hydraulic motor on the primary side and the hydraulic pump on the secondary side is formed or provided as an hydraulic engine having an inclined disc and axial piston(s), the angular position of the disc being settable by an adjusting mechanism. Such engines are also known as swash-plate or wobble disc engines.

In a further preferred embodiment, at least one of the hydraulic motor on the primary side and the hydraulic pump on the second side is a radial piston-type hydraulic engine, wherein the cylinder as rotating parts are secured to the shaft while the piston are supported on fixed structure, and in which the

eccentricity of the stator can be adjusted relative to the rotor.

Naturally, it is also possible to combine the above-described preferred embodiments, which means e.g. that an hydraulic engine may have its primary side, consisting of a bladed rotor and an annular stator accommodating the latter, coupled with a secondary side consisting of an inclined-disc type axial piston pump within the fundamental concept of the invention.

In a further possible embodiment, the hydraulic motor on the primary side may consist of an internally bladed rotor and a stator arranged inside the bladed rotor, the stator accommodated in the rotor at the same time forming the stator of the hydraulic pump representing the secondary side of the hydraulic converter or transformer, and in which the stator co-operates with an externally bladed rotor of the pump in such a way that the stator can be adjusted by an adjusting mechanism in relation to the two concentric rotors that are rigidly coupled together.

The hydraulic converter or transformer according to the invention seeks to offer advantages over the hitherto known mechanisms. It can be adjusted in two ways, i.e. both the primary side hydraulic motor and the secondary side hydraulic pump may be separately adjusted, thus covering a wider range of control and at the same time avoiding the considerable losses of energy due to the use of throttles.

With the aid of the invention one central pump can be used without a flow-dividing or distributing valve even where a plurality of independent working devices has to be operated and regulated separately. By connecting serially the primary sides of a plurality of hydraulic converters or transformers, mutually independent partial cycles can be created. In the case of mobile machines the invention eliminates the frequent need for gear dividers or distributors used to achieve mutually independent cycles.

In closed cycle drives, it is more economical to use an hydraulic converter (transformer) with a constant volume pump and motor than adjustable (variable) motors or pumps and their control gear.

In the hydraulic converter or transformer according to the invention the variation of the geometry of the working volume can be achieved or adjusted in various ways e.g. manually, mechanically, electrically, hydraulically or pneumatically.

The invention is further described in detail, purely by way of example, with reference to a preferred embodiment illustrated in the accompanying schematic drawings, wherein:

Figure 1 shows an embodiment of the hydraulic converter or transformer according to the invention having a bladed rotor and a cylindrical ring-shaped stator accommodating the rotor;

Figure 2 illustrates an embodiment of the hydraulic converter or transformer according to the invention consisting of an inclined-disc, axial piston hydraulic engine;

Figure 3 shows an enbodiment of the hydraulic converter or transformer according to the invention realised as a radial-piston hydraulic engine;

Figure 4 illustrates an embodiment of the hydraulic converter or transformer according to the invention, realised as a hydraulic engine with a hydraulic motor and a hydraulic pump having bladed rotors fitted into one another; and

Figure 5 is a cross-section taken along the plane A–A in Fig. 4.

In the preferred embodiment illustrated in Fig. 1, there is shown an hydraulic engine consisting of an hydraulic motor 1 on the primary side and an hydraulic pump 2 on the secondary side, each unit 1, 2 being provided with a respective rotor 3, 6 fitted with blades 8 and a respective annular stator 4, 5 eccentrically accommodating the rotors. The shafts 7 of the hydraulic motor 1 and the hydraulic pump 2 i.e. of the rotors 3 and 6 are drivingly coupled. In this embodiment, variation of the volumetric characteristics in both of the hydraulic motor 1 and the hydraulic pump 2 is executed by radial adjustment of the cylindrical stator rings 4 and 5 relative to the rotors 3 and 6, i.e. by variation of the eccentricity. The actual mechanism for effecting this variation is not considered to be part of the present invention and hence is not described here.

The hydraulic motor 1 is driven by a central pump (not shown) of the system. The rotor 3 of the hydraulic motor 1 rotates the rotor 6 of the hydraulic pump 2 via the shaft 7. The hydraulic pump 2 operates a working element or unit (not shown) connected in the cycle.

In the embodiment according to Fig. 2, the hydraulic motor 1 and the hydraulic pump 2 consist of hydraulic engines each with inclined discs 28 and axial pistons 23, and a common shaft 25. The geometry of the working chambers (volume) can be varied on both sides by tilting the inclined discs 28, by means of a respective adjusting element 29. By an alternating movement of the adjusting element 29, the angle of inclination of the inclined discs 29 and thus also the geometric working volume of the primary and/or secondary side is/are changed. The elements 29 are controlled by a control unit 22.

Here the primary side is an energy converter operating in the direction of flow. Under the effect of the through-flow of the working liquid which flows in one direction only, the rotor 24 together with pistons 23 will rotate in housing 27. The common shaft 25 will now rotate the secondary side, i.e. the rotor of the pump. Consequently the secondary side

delivers the liquid at a predetermined pressure and rate through a centrally positioned flow-distributing unit 26. The pressure and volume of the delivered liquid is proportional to the ratio of the geometric working volumes of the primary and secondary sides of the hydraulic converter.

The secondary side is a reversible energy converter or transformer; therefore, the quantity of the liquid delivered by it can be steplessly varied between zero and maximum in both directions.

In the preferred embodiment according to Fig. 3, both the primary and secondary sides of the hydraulic converter or transformer, i.e the hydraulic motor 1 and the hydraulic pump 2, are in the form of a radial piston-type hydraulic engine. Rotary parts or rotors 35 are secured to a common shaft 34 of the hydraulic motor 1 and the hydraulic pump 2 and accommodate the cylinders. In this embodiment, the pistons 36 are balls, but they may also be conventional pistons. The pistons 36 are supported on annular stationary parts or stators 37. The stators 37 are adjustable relative to the rotors 35 or rather, the eccentricity of the stator 37 relative to the shaft 34 may be varied by means of the adjusting element 32, shown only diagrammatically. The adjusting element 32 is connected with a control unit 31. The hydraulic converter or transformer is sealed off on both sides by cover plates 33 of the housing 38. The hydraulic motor 1 and the hydraulic pump 2 have a common flow-divider unit 39, which is placed in between the two.

The operation of this embodiment is entirely identical with the operation of the previously described embodiment with axial pistons, the only difference being that here it is not the angle of inclination of inclined discs or plates which is changed by the alternating motion of the adjusting element 32, but the magnitude of the eccentricity between the rotor 35 and the stator 37. In the preferred embodiment illustrated in Figs. 4 and 5, the hydraulic transformer or converter consists of an hydraulic pump 2 with a bladed rotor and a cylindrical ring stator accommodating the rotor, and an hydraulic motor 1 encompassing the hydraulic pump 2. The hydraulic motor 1 on the primary side is provided with a rotor 47 having internal blades 50 and with a stator 48 arranged inside the rotor 47. The stator 48 forms at the same time the stator of the hydraulic pump 2 provided with a rotor 49 having external blades 51. The rotor 47 of the motor 1 and the rotor 49 of the pump 2 are coupled by means of a disc or plate 43. The blades 50, 51 moving on the eccentrically disposed stator 48 absorb a predetermined volume of liquid on the primary side and deliver a predetermined volume of liquid on the secondary side. In this embodiment, the eccentricity of the stator 48 relative to the rotors can be varied with the aid of an adjusting element 45; therefore, the geometric working volume of the primary and secondary sides can be varied simultaneously. The adjusting element 45 is connected with a control unit 41. The hydraulic motor 1 and the hydraulic pump 2 are accommodated in a common housing 46 sealed by a cover 42.

Due to the fact that the geometric working volume of the hydraulic motor of the primary side and the hydraulic pump of the secondary side are changed simultaneously there is no possibility for a change of direction.

The invention is not restricted to the described embodiments because the primary side and the secondary side can be constructed in various forms. In certain cases it may be expedient to use a solution wherein the hydraulic motor is an axial piston type hydraulic engine of fixed, non-variable working volume, while the hydraulic pump is constructed as a bladed hydraulic engine of variable working volume. Other variants within the invention are also possible.

The hydraulic converter or transformer according to the invention may also be advantageously employed in the field of alternating-flow hydraulics which has recently been coming into more widespread use.

CLAIMS

1. An hydraulic converter or transformer comprising a primary side which includes an hydraulic motor and a secondary side which includes an hydraulic pump, the motor and the pump having respective drive shafts which are drivingly coupled together so as to prevent relative rotation therebetween, and at least one of the motor and the pump is of variable working volume.

2. An hydraulic machine according to claim 1, wherein at least one of the said motor and pump is an hydraulic engine having a bladed rotor and an annular stator which are radially adjustable relative to each other.

3. An hydraulic machine according to claim 1, wherein at least one of said motor and pump is an hydraulic engine having inclined plates provided with axial pistons and an adjusting mechanism for varying the angular position of the inclined plates.

4. An hydraulic machine according to claim 1, wherein at least one of said motor and pump is a radial piston engine and wherein the cylinders as rotors are secured to the shaft while the pistons are supported on the stators, the engine being fitted with an adjusting mechanism for changing the eccentricity of the stator relative to the rotor.

5. An hydraulic machine according to claim 1, wherein the said motor consists of a rotor provided with internal rotor blades and a stator accommodated inside the rotor, and at the same time the stator also constitutes the stator of the hydraulic pump on the secondary

side, the said pump consisting of a rotor provided with external rotor blades, and an adjusting mechanism for varying the position of the stator relative to the two concentric and rigidly interconnected rotors.

6. An hydraulic machine substantially as herein described with reference to Fig. 1 or Fig. 2 or Fig. 3 or Figs. 4 and 5 of the accompanying drawings.

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